

## Study Shows Consumers Find Grass-Fed Beef Acceptable

High feed-grain prices and the growing interest in “natural” foods have spurred both consumers and farmers to consider grass-fed beef, and a recent study may reinforce this trend.

According to John Comerford, associate professor of dairy and animal science in the College of Agricultural Sciences, the study showed that most consumers find the taste and tenderness of grass-fed beef acceptable in blind taste tests. He recommends that producers look for ways to interest more potential customers in grass-fed beef.

“There are also some important human health benefits related to components of grass-finished beef,” says Comerford, who oversees the University’s beef research and extension programs. “While there is no difference in the cholesterol content of grass- and

grain-finished beef, and the limited amount of conjugated linoleic acid in cooked steaks is too small to do much for human health, there is still an advantage in the increased omega-3 fat content in grass-fed beef.”

Emily Steinberg, who recently completed her master’s degree in the Department of Dairy and Animal Science, conducted consumer evaluations of cooked grass-fed beef steaks and analyzed production issues for farmers. Her work suggests that some of the preconceived notions held by farmers about the physical type of the cattle and the length of the grazing season needed for high-quality grass-fed beef may not be true.

“The results of the study showed that most consumer evaluations of the cooked meat were not influenced by frame sizes of the cattle, weight at harvest, range of grazing period from 120 to 180 days, and final fat composition of the carcass,” Comerford explains. “However, all of the cattle must have plenty of high-quality forage to consume

daily plus be harvested at eighteen months of age or less. None of the production practices or consumer values studied were related to the final fatty acid profiles or cholesterol content of the steaks.”

Comerford notes that these results give grass-fed-beef producers tremendous flexibility in the kind of cattle they feed and the way they market their cattle. “Not surprisingly, we found that finishing productive, healthy cattle on good pastures and stored forages for at least 120 days is far more important to consumer acceptance of the product than cattle’s frame size or how fat the animals are.

“In fact, we found cattle that had the fattest final carcasses actually had lower scores from the consumer panels because of the influence of fat on beef flavor,” Comerford says. “Further research will attempt to reduce the inconsistency of consumer scores for many traits of the meat by postharvest interventions such as marinades and carcass aging.”

—Jeff Mulhollem



PHOTO: ISTOCKPHOTO.COM



PHOTOS: GREG GREICO

## Seeding Energy Crops from the Air

Glen Cauffman wanted to get the word out about Penn State's aerial seeding of bioenergy crops on 300 acres just north and east of the University Park campus last September for two reasons.

First, he didn't want State College-area residents to be concerned about a small plane repeatedly swooping low over fields near town. Aerial agricultural applications are still rare enough in Pennsylvania that residents might have feared some sort of terrorism. He wanted to avoid any confusion.

But more importantly, the manager of farm operations and facilities in the College of Agricultural Sciences wanted the public to know that the University is serious about helping the country solve its energy crisis. "We want to lead the way in showing farmers how to intersperse energy crops with their crop rotations to produce food and fuel on the same land," he says. "By seeding from the air in late summer, we can establish an energy-feedstock cover crop before the food crop is harvested, effectively getting more out of the growing season. Penn State wants to demonstrate that society can have its biofuel and food, too."

In this case, the energy crop was canola, which must be planted



**From left, Brian Macafee, assistant manager of farm operations, Glen Cauffman, manager of farm operations and facilities, and pilot Jeff Chorman review maps to determine exact locations where seed will be dropped.**

in early September in central Pennsylvania to survive the winter. The food crops were standing corn and soybeans, which often are allowed to dry down before being harvested in November. A specially equipped aircraft precisely delivered the seed at a speed of 160 miles per hour utilizing GPS technology to pinpoint the right fields and the swath width.

Canola was chosen, according to Cauffman, because the grain is 40 percent oil that can be used to fuel tractors and harvesters. "Canola typically can produce 125 gallons of biodiesel fuel per acre," he says. "Canola meal—what remains after the oil is extracted—is high in protein and can be used as a high-quality supplement to feed

the University's livestock."

For several years Penn State Farm Operations has been growing canola and squeezing the seed to yield oil and meal, Cauffman notes. "The oil is being used in a collaborative study with machinery manufacturer New Holland to test straight canola oil [without chemical processing] in modified diesel engines," he says. "This concept will enable farmers to be self-sufficient for tractor fuel and will enhance food industry security by reducing dependence on foreign petroleum."

Canola is considered both an energy crop and a cover crop. Cover crops are important in preventing soil erosion and protecting surface and groundwater, Cauffman

explains. "By aerial seeding in late summer, cover crops are given a jump start in germinating and accumulating biomass as the food crops are maturing and drying down. Canola is harvested with a combine in late June or early July, after which another food or feed crop is planted."

Making farmers adept and comfortable with implementing this food-fuel rotation is seen as a key to the nation's ability to lessen its dependence on imported oil. It is an environmentally sound practice as well, according to a recent Chesapeake Bay Commission report that encourages farmers to apply cover crops to their land, stressing that bioenergy cropping systems are beneficial to the water quality of the bay.

Another benefit, Cauffman points out, is that canola sequesters fertilizer that remains from the corn or soybeans, preventing it from leaching into streams or groundwater. Those fertilizer nutrients are held and made available for the next crop.

"Penn State's College of Agricultural Sciences hopes to demonstrate that canola can be both a viable winter energy crop and a winter cover crop when seeded in September," says Cauffman. "Canola has a taproot that grows deep into the subsoil, which enhances soil quality."

—Jeff Mulhollem

## Pesticide Buildup Could Lead to Poor Honey Bee Health

Honey bees industriously bring pollen and nectar to the hive, but along with the bounty comes a wide variety of pesticides, according to researchers in the College of Agricultural Sciences. Add the outside assault to the pesticides already in the waxy structure of the hive, and bee researchers see a problem difficult to evaluate and correct. However, an innovative approach may mitigate at least some beeswax contamination.

The researchers presented their analysis of pollen, brood, adult bees, and wax samples recently at the 236th national American Chemical Society meeting in Philadelphia. Those results show unprecedented levels of fluralinate and coumaphos—pesticides used in the hives to combat parasitic varroa mites—in all comb and foundation wax samples. They also found lower levels of seventy other pesticides and metabolites of those pesticides in pollen and bees.

“Everyone figured that the acaricides [anti-varroa-mite chemicals] would be present in the wax because the wax is reprocessed to form the structure of the hives,” says Maryann Frazier, senior extension associate in entomology. “It was a bit of a shock to see the levels and the widespread presence of these pesticides.”

While the researchers expected the presence of the chemicals available to treat varroa mites in the hives, the other pesticides’ levels were also surprising. All of the bees tested showed at least one pesticide, and pollen averaged six pesticides with as many as thirty-one in a sample.

“We already had in place ways to test for viruses, bacteria, and fungi, but it was difficult to find an analytical laboratory that could analyze for unknown pesticides,” says Christopher Mullin, professor of



PHOTO: ISTOCKPHOTO.COM

entomology. “We needed to take a comprehensive look at all pesticides, not just those associated with beekeeping.”

They eventually turned to the National Science Laboratory of the U.S. Department of Agriculture’s Agricultural Marketing Service. That lab tests commodities such as milk, fruits, and vegetables to ensure that they meet national and international standards.

“When we began doing this work, honey was not regularly analyzed, and bee pollen was not a commodity and so was not analyzed,” says Mullin. “We decided to go with the types of screening the lab does for milk and apples—these tests look at over 170 pesticides. Now, honey is included in the commodities to be analyzed.”

While beekeepers will have a difficult time controlling pesticide exposure outside the hive, the researchers tested a method for reducing the acaricide load in beeswax. Using gamma radiation from

a cobalt 60 source housed at Penn State’s Breazeale Reactor, they irradiated the sheets of beeswax that beekeepers use as the structural foundation for the bees to build their combs. Applying radiation levels at the high end of the range used to irradiate foods, the team was able to break down about 50 percent of the acaricides in the wax.

“Gamma radiation is often used to kill viruses and other disease-causing agents,” says James Frazier, professor of entomology. “Commercial irradiation firms usually decontaminate medical instruments or foods.” Some beekeepers already irradiate their equipment to eliminate disease-causing agents, the researchers note.

Beekeepers cannot manage the environmental pesticide contamination as easily as the wax contamination. The U.S. Environmental Protection Agency does regulate and monitor pesticides but does not have the ability to monitor the interaction of these chemicals.

With the large number of pesticides found in bees and pollen, interactions are likely.

“We are finding fungicides that function by inhibiting the steroid metabolism in the fungal diseases they target, but these chemicals also affect similar enzymes in other organisms,” says James Frazier. “These fungicides, in combination with pyrethroids and/or neonicotinoids, can sometimes have a synergistic effect hundreds of times more toxic than any of the pesticides individually.”

It’s not clear what implications these findings have for Colony Collapse Disorder (CCD), the syndrome that has decimated honey bee colonies across the country. Bees affected by CCD are not dying in their hives but are not returning to their hives. James Frazier notes it is difficult to observe bees outside the hive, and chronic exposure to pesticides may cause behavioral changes that are unmonitored.

“We do not know that these chemicals have anything to do with Colony Collapse Disorder, but they are definitely stressors in the home and in the food sources,” he says. “Pesticides alone have not shown they are the cause of CCD. We believe that it is a combination of a variety of factors, possibly including mites, viruses, and pesticides.”

The researchers, who also include research assistant Sara Ashcraft, form a team uniquely suited to examine the honey bee pesticide problem because they combine a toxicologist (Mullin), a physiologist (James Frazier), and an extension specialist with connections to beekeepers across the country (Maryann Frazier).

“We now want to look at small versus large operations and organic versus nonorganic operations to see if there are differences,” says Maryann Frazier.

The U.S. Department of Agriculture, the National Honey Board, beekeeper organizations, and concerned individuals supported this work.

—Andrea Messer

## Safe Farming Practices Offer Hope for Stopping Tainted-Food Crises

With foodborne illness outbreaks linked to produce popping up periodically in the nation's headlines, supermarket managers are grasping for ways to ensure that the fresh fruits and vegetables they sell are safe. But a food-safety specialist in Penn State's College of Agricultural Sciences says farmers have a role to play in reducing the risk of contamination.

Luke LaBorde, associate professor of food science, says growing safe spinach, onions, tomatoes, or other produce is a quality-control issue, and farms that adhere to a series of federally developed recommendations are less likely to become involved in an outbreak of foodborne illness.

"Microbial contamination of fresh produce can happen anywhere," LaBorde says. "Although there are no government-mandated food-safety regulations for farms, the U.S. Food and Drug Administration has a list of recommendations—the *Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables*—that offers techniques for preventing on-farm produce contamination."

These techniques—called "good agricultural practices," or GAPs—are designed to prevent contamination of produce on the farm through personal sanitation, correct use of manures and compost, proper bathroom facilities, and monitoring of other areas where contamination can occur.

"Farmers who adhere to these practices are using proven food-safety control measures to prevent crop contamination," LaBorde explains. "There are no laws that require growers to use GAPs, but grocery stores, restaurants, and fresh-cut processors who want to protect themselves from liability are



PHOTO: BIGSTOCKPHOTO.COM

demanding that suppliers demonstrate that they are using GAPs."

GAPs guidelines present growers with proven practices and standards in health and hygiene, water quality, soil supplements, and environmental hazards. To provide grocery stores and restaurants with evidence that they are following scientifically supported practices, growers typically must submit to an inspection from an independent, third-party auditor at some point during the harvest season.

The Fresh Produce Audit Verification program, a new U.S. Department of Agriculture service, is available through funding support from the Pennsylvania Department of Agriculture. In addition, Penn State Cooperative Extension and the Department of Food Science are developing a GAPs educational program to help growers understand farm food-safety risks and develop a food-safety plan.

Visitors to Penn State's GAPs Web site ([foodsafety.psu.edu/gaps](http://foodsafety.psu.edu/gaps))

**These techniques—called "good agricultural practices," or GAPs—are designed to prevent contamination of produce on the farm through personal sanitation, correct use of manures and compost, proper bathroom facilities, and monitoring of other areas where contamination can occur.**

can access background information on the audit process, forms for conducting a self-inspection, templates for writing their safety plan, instructions on how to arrange for a third-party audit, and links to other farm food-safety resources.

"One day, we'll see more implementation of GAPs, and farm

inspectors and consumers will have a way to identify the inspected farms—perhaps a placard or label at the grocery store," LaBorde says. "But right now, the burden is on the consumer to ask the right questions. You can ask the produce grower at a roadside stand or farmers' market or the produce manager in a grocery store if GAPs were used. If they don't know, you can decide whether the risk is acceptable to you."

LaBorde reminds consumers that, despite the publicity accorded to foodborne illness outbreaks, the risk of buying contaminated product is quite low. "We don't hear about the 99.99 percent of the produce that's perfectly safe," he says. "When we have tainted products shipped in from different places in this or other countries, we hear a lot about it. It's a small amount, but the implications are devastating, not only for the economic viability of the industry, but also to the people who get sick."

—Gary Abdullah

## Researcher Helps Design Smithsonian Exhibit on Soil

A soil scientist in the College of Agricultural Sciences helped lead the design of a temporary exhibition that opened last summer at the Smithsonian's National Museum of Natural History in Washington, D.C. "Dig It! The Secrets of Soil" exhibition reveals the complex world of soil and how this hidden ecosystem supports nearly every form of life on Earth.

"Seven years ago, a visit to the Natural History Museum inspired me and another soil scientist, the late Tom Levermann, to approach the Smithsonian about an exhibit devoted entirely to soils," says Patrick Drohan, assistant professor of pedology in the Department of Crop and Soil Sciences. "The enthusiasm of the entire soil community and the Smithsonian researchers and curators, along with major financial support from several organizations, turned the idea into reality."

"Dig It!" shows how every type of soil is unique. Visitors can observe the way water moves through different soils in tumbler tubes containing sand, silt, clay, and loam. The flow of water through soil can affect minerals and gases and all life that depends on soil. Soil color tells fascinating stories about mineral compositions and soil formation or history. "Dig It!" color cards help visitors unveil the stories behind soil samples. Visitors also can get in touch with their inner detective and learn about the soil food web in the "Matters of Life and Death Theater."

The exhibit includes audiovisual and interactive components, from a set of interactive soil stratigraphy blocks to a crime-scene-investigation video focusing on the processes of decay. Fifty-four soil samples representing each U.S. state and territory and the District of Columbia, as well as touchable



PHOTOS: GREG GREICO



**Patrick Drohan (above), who studies the properties of soil and the impact of human activities on soil and ecological systems, played a major role in designing "Dig It! The Secrets of Soil" (left), an exhibit on display at the Smithsonian's Museum of Natural History.**

soil models from around the globe, will help curious visitors discover a world teeming with life. In fact, so many organisms contribute to the health of soil that scientists have not even named them all.

After examining soil close up, exhibition visitors can step back and see the “big picture” with a world map and interactive stations that present the connection between soil and global systems. An evocative video explains soil’s role as a “secret ingredient” in such household goods as medicines, food, wine, textiles, paint, cosmetics, and pottery.

Drohan hopes the exhibit raises awareness of the need to conserve soils, which are as important to life on Earth as water and air. “Just as we lose animal and plant species to extinction, we also are seeing soils damaged or lost due to pressures from human-caused destruction, which can put life at risk,” he says. “Worldwide, the effects of global warming are predicted to lead to the disappearance of permafrost within one thousand years, which would result in the extinction of a whole order of soils.

“Many examples throughout history also exist of civilizations rising and falling in part due to their management of soil. The best soils for food production are often ideal for building sites, and their favorable characteristics attract intensive development, often resulting in their degradation and significant economic loss,” he adds.

The exhibition, which will run through Jan. 3, 2010, is sponsored by the Soil Science Society of America and the Nutrients for Life Foundation, which is underwritten by The Fertilizer Institute. Photos of the exhibit can be found online at [live.psu.edu/stilllife/1749](http://live.psu.edu/stilllife/1749).

More information about the National Museum of Natural History is available at [www.mnh.si.edu](http://www.mnh.si.edu) or by calling Smithsonian Information at 202-633-1000.

—Vicki Fong

## Ceramic Material Revs Up Microwaving

Quicker microwave meals that use less energy may soon be possible with new ceramic microwave dishes, and according to the scientists responsible, this same material could help with organic waste remediation.

“Currently, food heated in a microwave loses heat to the cold dish because the dishes are transparent to microwaves,” says Sridhar Komarneni, Distinguished Professor of Clay Mineralogy in the College of Agricultural Sciences. “The plates are still cool when the cooking is completed.”

Materials are transparent to microwaves because the microwaves do not interact with the molecules in standard tableware. With liquids such as water, the microwaves cause the molecules to move back and forth, creating heat.

Komarneni—working with Hiroaki Katsuki and Nobuaki Kamochi of the Saga Ceramic Research Laboratory in Saga, Japan—developed a ceramic from petalite and magnetite sintered together that heats up in the microwave without causing equipment problems the way most metals do. They reported their material in a recent issue of *Chemistry of Materials*.

Petalite is a commonly occurring mineral that contains lithium, aluminum, and silicon and often is used to make thermal-shock-resistant ceramics because it expands very little when heated. Ceramic sintering uses powdered minerals pressed together hard to form green bodies. These green objects are fired first at low and then high temperatures.

When the petalite and magnetite are fired together, the magnetite converts to an iron oxide that heats up when placed in a microwave. A rice cooker made of this material cooked rice in half the time it normally takes in a nonheating microwave rice cooker.

“Rice cooks very well with these dishes,” says Komarneni, who is also a member of Penn State’s Materials Research Institute. “Dishes heated by themselves or with food could keep the food hot for up to fifteen minutes. One might even cook a pizza on a plate and then deliver it hot.”

However, those accustomed to cooking in a microwave will need to remember that the plates are hot and will burn bare hands. Potholders are again necessary.

Food preparation applications abound. A company in Arita, Japan—long a locus of ceramic manufacturing—called Asahi Ceramics Research Company is manufacturing microwave ware.



PHOTO: ISTOCKPHOTO.COM

The material’s microwave heating properties suggest another use. Because it expands very little when heated, the petalite magnetite material does not shatter under rapid microwave heating and cooling as other materials might. The researchers created a plate of the petalite magnetite ceramic and coated the solid plate structure with cooking oil. After heating for 120 seconds, 98 percent of the oil was gone, decomposed into its components.

“We used cooking oil because it is an innocuous substance,” says Komarneni. “We could, perhaps, use this material in a closed system to decompose organic contaminants in soil.”

The researchers believe that once optimized, the material could be used for a variety of remediation applications at a lower energy cost and with less residue than many current methods.

—Andrea Messer

## Novel Fungus Helps Beetles Digest Hardwood

A little-known fungus tucked away in the gut of Asian longhorned beetles helps the insect munch through the hardest of woods, according to a team of entomologists and biochemists. Researchers say the discovery could lead to innovative methods of controlling the invasive pest and potentially offer more efficient ways of breaking down plant biomass for generating biofuels.

Microbes in the gut of insects are known to break down cellulose, but little is known about how, or whether, insects degrade lignin. This natural polymer helps plants stay upright and protects them from most forms of microbial attack.

“Lignin is nature’s plastic, and any organism that wants to get to the sugars in a plant has to be able to get past this protective barrier,” says Ming Tien, study co-author and professor of biochemistry and molecular biology in Penn State’s Eberly College of Science. “We suspect that the fungus produces enzymes that help the beetles degrade lignin.”

Before this report, it was thought that insects were unable to extensively break down lignin and that they got around the problem either by feasting on wood that has already degraded or by living close to fungi that can degrade the wood for them. But this theory fails to explain the ability of insects to feed and grow within healthy, living trees.

“How these insects are able to circumvent this plastic wall [lignin] and get at the goodies, the sugars, behind it has remained a mystery,” says Tien, who was recruited by Kelli Hoover, co-author and associate professor of entomology in the College of Agricultural Sciences, and Scott Geib, lead author and Penn State doctoral student in entomology, to tease out an explanation.



PHOTO: JOSHUA PETER KAFFER

The Asian longhorned beetle is one such insect that attacks healthy trees and bores through the hardwood to get at the succulent, energy-rich matter inside. In the process, this invasive pest from China grows nearly 300-fold from being about the size of a grain of rice to a few inches in length.

Hoover and her colleagues speculated that the beetle could be harboring a community of microbes in the gut, which helps in breaking down lignin.

The researchers compared the chemical structure of nondegraded wood before and after it had passed through the gut of two wood-eating insects. To measure the degree of change in the lignin, they first fed pin oak wood to Asian longhorned beetles. Next they fed ponderosa pine wood to the Pacific dampwood termite, an insect that typically eats only dead wood.

Chemical analyses of feces from the two bugs indicated that they are able to alter the chemical structure of lignin by selectively adding or removing certain groups of molecules from the polymer.

Such alterations, says Geib, make it easier for the insect to break down wood.

“This fungus has genes that then make enzymes,” explains Hoover, whose team’s findings appeared in the *Proceedings of the National Academy of Sciences*. “We have been able to detect messages from the [fungal] DNA, which get translated into enzymes.”

While the researchers have identified the fungus residing in the gut of the Asian longhorned beetle, they have yet to find one in the gut of the termite. “The types of chemical changes we see in the beetle are similar to those seen in the white-rot fungus,” says Geib. “Changes that we see in the termite are similar to those in the brown-rot fungus. The chemical changes to the lignin are similar.”

However, Geib cautions that while the gut-borne fungus is certainly a key player in degrading wood, it may just be part of a bigger picture. “It is likely that there is an interaction among enzymes produced by the fungus, hundreds of bacteria within the insect gut,

and the insect itself,” he says. “It is a consortium that is doing the job.”

If researchers manage to identify some of these key microbes, he says it might be possible to selectively target just those bacteria to impair the growth of Asian longhorned beetles, which have the potential to severely damage the lumber and maple syrup industries.

Both Geib and Hoover, who study Asian longhorned beetles, believe they may have stumbled on a novel evolutionary adaptation in the insect world.

“This type of fungus [in the Asian longhorned beetle] is known to cause disease in plants,” says Hoover, whose work is funded by the Alphawood Foundation and the College of Agricultural Sciences. “But this particular strain appears to be unique. It looks like these insects somehow acquired the fungus to live in their gut and help them break down wood.”

She also points out that these fungi are more efficient than their free-ranging counterparts. While those fungi take months, even years, to break down wood, the gut-borne fungi seem to do it much faster. Researchers say the speedy process could potentially be harnessed to produce biofuel.

“Getting rid of the lignin barrier and making the cellulose more accessible is the most expensive and environmentally unfriendly part of making ethanol from biomass,” says Geib. The team’s discovery, he adds, could lead to the development of cheaper and more efficient enzymes for converting wood into ethanol.

Other researchers contributing to the project included John Carlson, professor of molecular genetics in the School of Forest Resources, and Maria del Mar Jimenez-Gasco, assistant professor of plant pathology in the College of Agricultural Sciences, as well as scientists from Purdue University and Old Dominion University.

—Amit Avasthi

## Penn State and Partners Bring New Disease-Management Tool to Nepal

Penn State's College of Agricultural Sciences, as part of a consortium that includes Virginia Tech and Ohio State universities, is collaborating with researchers from Nepal Agricultural Research Council and Winrock International to develop a new grafting technology to combat diseases and pests in tomatoes and eggplants.

Tomatoes and eggplants are some of the most popular vegetables in the world. Because of their high demand, they also are popular among growers wanting to increase their income. New technologies such as plastic tunnels are helping promote the off-season cultivation of tomatoes in countries across the globe. But various pests, such as

bacterial wilt, root knot nematodes, tomato fruit worm, and shoot and fruit borer of eggplant, decrease yields and have been known to destroy entire crops.

Ed Rajotte, professor of entomology, is collaborating with researchers in other countries to find solutions through the Integrated Pest Management (IPM) Collaborative Research Support Program. The fifteen-year-old program, managed by Virginia Tech, is part of the United States Agency for International Development, which supports research, education/training, and information exchange among U.S. and developing-country institutions. "The program focuses on participatory and collaborative IPM research and education programs for horticultural crops and other food-production systems," Rajotte explains. "Integrated pest management provides economical methods for managing pests such as insects, diseases, weeds, and rodents using tactics that are eco-

nomical, safe for people, and non-threatening to the environment."

In Nepal, bacterial wilt in tomato and eggplant is prevalent in the foothills and valleys where the environment is warm and humid. In the absence of proper pest-management methods, yield losses could approach 100 percent. Root knot nematode is another severe pest of tomatoes and eggplants. Many farmers in Nepal report related losses of about 40 percent.

According to Rajotte, management of these pests is very difficult due to wide host range, location, and variability among the pathogens. In addition, there are

**The program focuses on participatory and collaborative IPM research and education programs for horticultural crops and other food-production systems.**

no commercial pesticides available for sustainable control, and disease-resistant plants are not readily available.

"Grafting eggplant and tomato varieties onto resistant wild *Solanum* rootstocks has proved to be effective for controlling bacterial wilt and root knot nematode in Bangladesh, one of the program's collaborating countries," Rajotte says. "One rootstock species, *S. silymbriifolium*, was chosen because it adapts to local growing conditions, is resistant to soilborne diseases, and grows quickly to provide rootstock seedlings faster. In addition, these grafting techniques can be done cheaply so that grafted plants can be produced locally at the village level. In Bangladesh, grafted plants yielded significantly higher than nongrafted plants in farmers' fields."

The grafting technique developed in Bangladesh has been transferred and is being evaluated in Nepal. Local testing of any new technology is important because different ecological factors may necessitate adjustments in the technique. Grafting is especially important to Nepal because its higher altitudes allow tomato production when it is too hot in India.

A thriving tomato export industry has developed in Nepal, but it has been plagued by soilborne diseases. So far, the grafting technique is working well and the farmers are getting better yields. "Fifteen farmers from six different districts of Nepal have been trained and are acting as nursery growers to supply local farmers with grafted plants," says B. K. Gyawali, the program's Nepal site coordinator. "The availability of grafted plants will reduce pest-control costs, improve yields, and strengthen the supply chain for vegetables."

More information about the project and the Integrated Pest Management Collaborative Research Support Program is available online at [www.oired.vt.edu/ipmcrsp](http://www.oired.vt.edu/ipmcrsp).

—Kristie Auman-Bauer



PHOTO: PROVIDED BY ED RAJOTTE

**These Nepalese women are part of a cooperative that was formed to grow tomatoes in the off-season and sell them to consumers in India, where it is too hot to grow tomatoes in summer. New grafting techniques are helping growers in Nepal increase yields by avoiding disease-related crop losses.**